United States
Department of
Agriculture

Soil
Conservation
Service

Hydrology Training Series

Module 107 - Hydrographs

Study Guide

Engineering
Hydrology Training Series
Module 107

Hydrographs

National Employee Development Staff
Soil Conservation Service
United States Department of Agriculture
September 1989

Preface

This module consists of a study guide that provides an introduction and overview of hydrographs and hydrograph development. It is not a "design" module.

Proceed through this module at your own pace. Be sure you completely understand each section before moving on. If you have questions or need help, please request assistance from your supervisor. If your supervisor cannot clear up your problems, he/she will contact the state appointed resource person. The resource person is familiar with the material and should be able to answer any questions you may have.

Be sure to write out your answers to the included activities. This will help to reinforce your learning. After completing each activity, compare your answers with the included solution.

Acknowledgment

The design and development of this training module is the result of a concentrated effort by practicing engineers in the Soil Conservation Service. The contributions from many technical and procedural reviews have helped make this module one that will provide neededknowledge of hydrology and hydraulics to SCS employees.

Module Description

Objectives

Upon completion of this module, the participant will be able to:

1. Define hydrograph.
2. List the various types of hydrographs.
3. Describe the various hydrograph components.
4. List the uses of hydrographs in SCS.

The Participant should be able to perform at ASK Level 2 (Understanding) after completing the module.

Prerequisites

Module 101– Introduction to Hydrology.

Length

Participant should take as long as necessary to complete this module. Training time for this module is approximately one hour.

Who May Take the Module

This module is intended for all SCS personnel who need an introduction or overview of hydrographs.

Method of Completion

This module is self-study, but the state or NTC should select a resource person to answer any questions that the participant's supervisor cannot handle.

Content

This module lists the various types of hydrographs, defines their components and lists the uses of hydrographs in SCS.

Contents

Introduction

A hydrograph is a graph showing stage, discharge, velocity, or other properties of water flow with respect to time. When the stage is plotted against time, the graph is a stage hydrograph (which is the form of a stream gage record). When the discharge is shown against time, the graph is a discharge hydrograph. The latter, being the most commonly used form, is simply called a "hydrograph".

This module describes the various types of discharge hydrographs (hereafter referred to as "hydrographs"), the various graphic features of a hydrograph, and the most common uses of hydrographs in SCS work.

Types of Hydrographs

In its simplest form, a hydrograph is a graphical representation of runoff rate against time (Figure 1). It shows the time distribution of runoff at the point of measurement or computation, reflecting the complex characteristics of the watershed by a single curve. One characteristic, the duration or time of flow, is nearly a constant for a particular watershed, regardless of the value of the peak flow from a specific storm, assuming a constant storm duration.

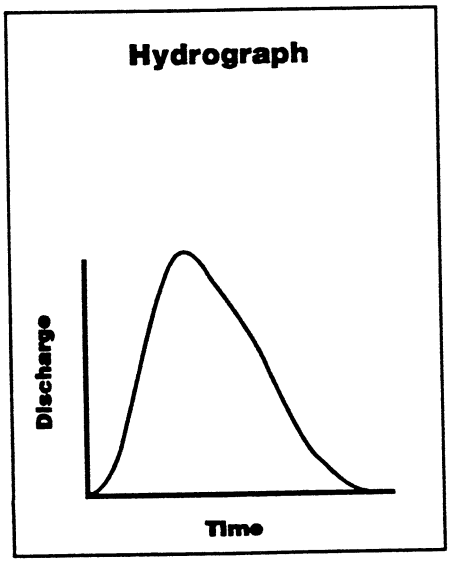


Figure 1. *Natural hydrograph, runoff rate vs. time*

There are several types of hydrographs which include:

1. Natural hydrograph
2. Unit hydrograph
3. Dimensionless unit hydrograph
4. Synthetic hydrograph
5. Dam breach hydrograph (Special case - natural or synthetic)

Natural Hydrograph

A natural hydrograph is one recorded at a stream gaging site and is a fingerprint of the upstream drainage area's response to rainfall (Figure 1).

Unit Hydrograph

A unit hydrograph is a natural or synthetic hydrograph representing one inch of runoff, uniformly from the watershed during a specified time. In other words, the area under the graph is actually a volume of one inch of runoff.

Dimensionless Unit Hydrograph

A dimensionless unit hydrograph is a generic combination of many natural unit hydrographs. The ordinate and abscissa scales are ratios of the discharge with respect to the peak discharge and the time relative to the time to peak, respectively (Figure 2).

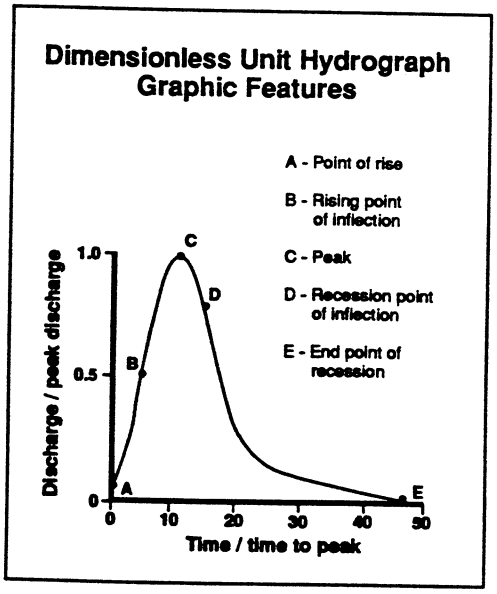


Figure 2. *Dimensionless unit hydrograph, peak discharge vs time to peak.*

Synthetic Hydrographs

A synthetic hydrograph is calculated based on watershed and storm characteristics. (In SCS, soils, land use, vegetative cover, size, slope, and time of concentration are important watershed characteristics.) Synthetic hydrographs are used to simulate natural hydrographs for ungaged watersheds
(Figure 3).

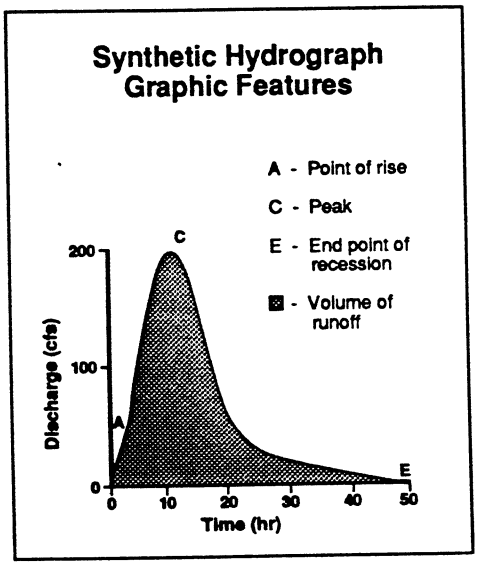


Figure 3. *Synthetic hydrograph.*

The peak flow charts in Chapter 2, Engineering Field Manual and in Technical Release 55 were developed from the peaks of many synthetic hydrographs. These charts are used in the design of conservation practices, such as grassed waterways, channels, terraces, ponds, etc.

Two additional uses made of synthetic hydrographs are for reservoir routing and reach routing (Figure 3a). These are important hydrographs in SCS.

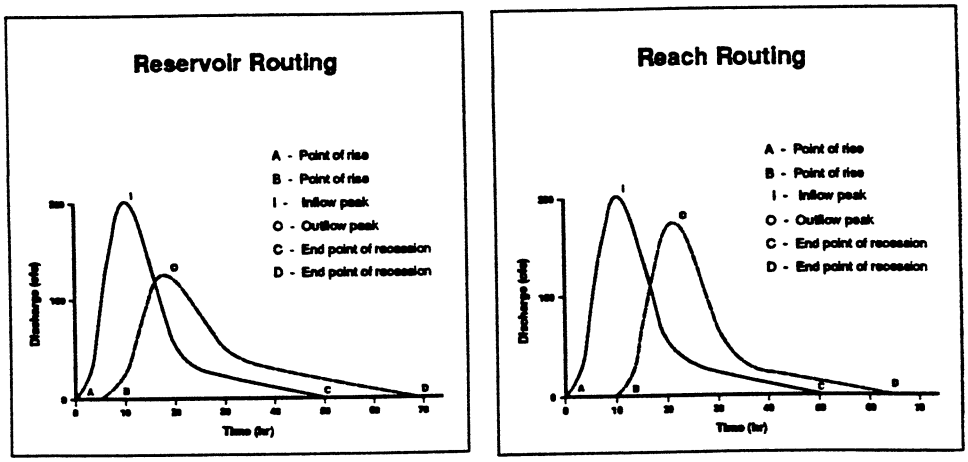


Figure 3a. *Two uses of synthetic hydrographs: reservoir routing and reach routing.*

Dam Breach Hydrograph

A dam breach hydrograph represents the sudden release of water from the impoundment due to a breach, followed by the draining of the reservoir. The volume represented by the hydrograph is the storage volume of the reservoir released during the breach. Factors affecting the shape of the breach hydrograph include: size and shape of breach, depth of water at the dam,volume of stored water, surface area of reservoir, and shape (especially length) of reservoir. A breach hydrograph can be natural (recorded) or synthetic (a simulation). Figure 4 shows a breach hydrograph from the instantaneous failure of a dam.

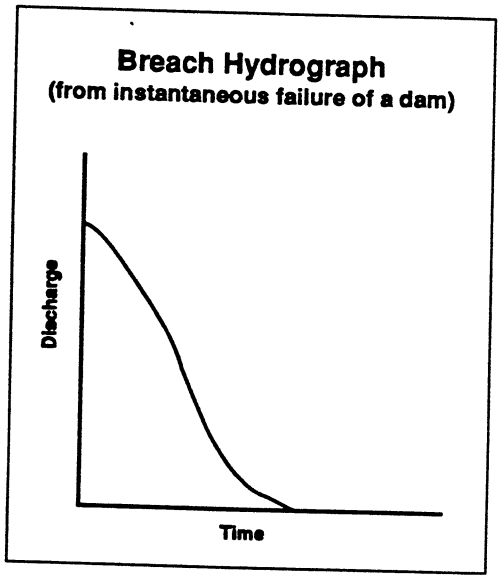


Figure 4. *Breach hydrograph from the instantaneous failure of a dam*

Physical Factors that Influence Shape

The most common physical factors influencing the shape of a hydrograph are:

1. Topography (slope).
2. Watershed shape (fan/elongated).
3. Size of watershed.
4. Stream channels and flood plains (size, depth, width, etc).
5. Rainfall (amount, duration, distribution).
6. Land use and vegative cover.
7. Soil types.

Hydrograph Components

A hydrograph is made up of several parts which, taken together, reveal considerable information about the watershed. Take, for example, the hydrograph shown in Figure 5.

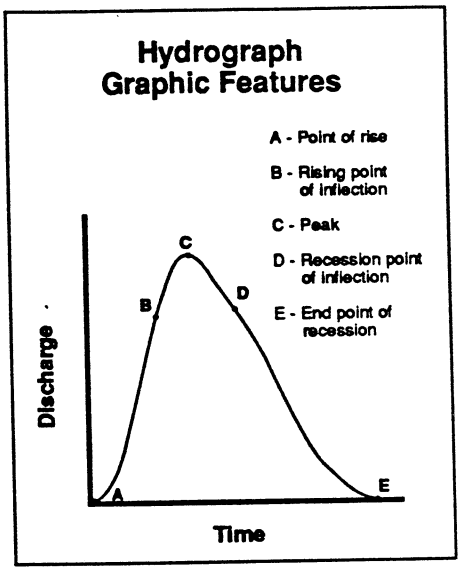


Figure 5. *Hydrograph showing graphical feature*

Graphical Features

Graphical features of a hydrograph include the following points:

A. Point of rise

B. Rising point of inflection

C. Peak

D. Recession point of inflection

E. End point of recession

These points, in turn, delineate the following segments (Figure 6):

A-C Rising limb - Generally reflects storm characteristics.

B-D Crest segment - Highest concentration of runoff.

C-E Recession limb - Withdrawal of stored water.

A-E Base time of hydrograph - Duration of runoff.

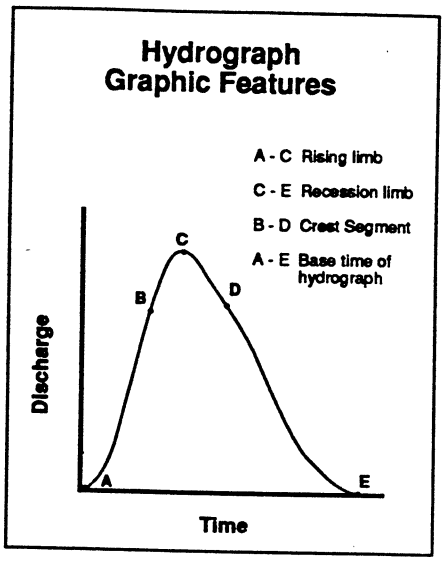


Figure 6. *Hydrograph showing segments*

The area under the hydrograph (Figure 7) is the curve described by points A, B, C, D, E, and the abscissa, and represents the volume of runoff.

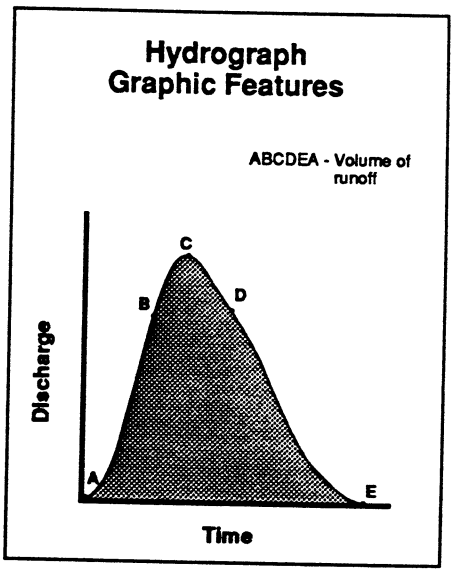


Figure 7. *Hydrograph showing volume of runoff.*

Activity 1

At this time, complete Activity 1 in your Study Guide to review the material just covered. After finishing the Activity, compare your answers with the solution provided. When you are satisfied that you understand the material, continue with the Study Guide text.

Activity 1

1. A hydrograph is a graph showing _____, _____, _____, or other properties of water flow with respect to time. When the stage is plotted against time, the graph is a _____-hydrograph. When the discharge is shown against time, the graph is a _____ hydrograph. The latter being the most commonly used form, is simply called a _____.

2. List the various types of hydrographs.

   a. _____ hydrograph

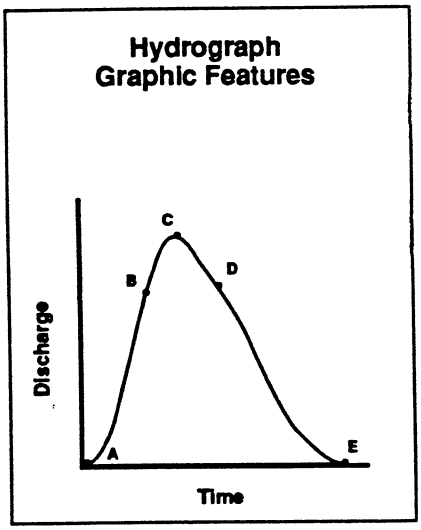
   b. _____ hydrograph

   c. _____ hydrograph

   d. _____ hydrograph

   e. _____ hydrograph

3. Identify the various hydrograph components shown on the following three hydrographs:



A. _____

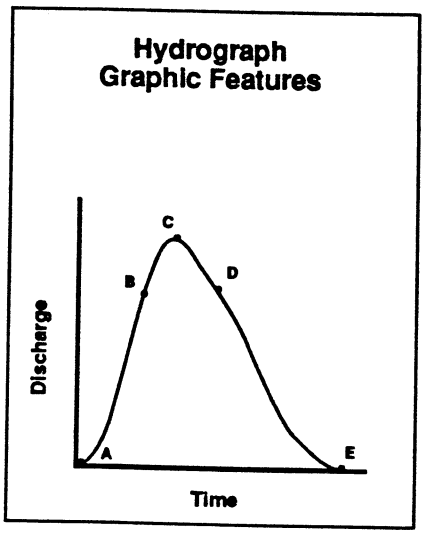
B. _____

C. _____

D. _____

E. _____

3. *Continued*

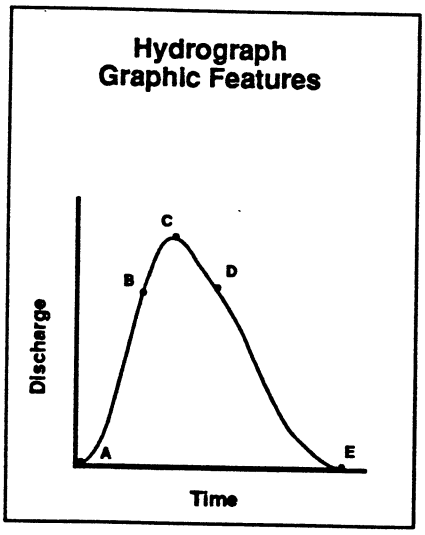


A - C _____

C - E _____

B - D _____

A - E _____



ABCDEA _____

_____

_____

_____

Activity 1 – Solution

1. A hydrograph is a graph showing stage, discharge, Volume of runoff, or other properties of water flow with respect to time. When the stage is plotted against time, the graph is a stage hydrograph. When the discharge is shown against time, the graph is a discharge hydrograph. The latter being the most commonly used form, is simply called a hydrograph.

2. List the various types of hydrographs.

   a. Natural hydrograph

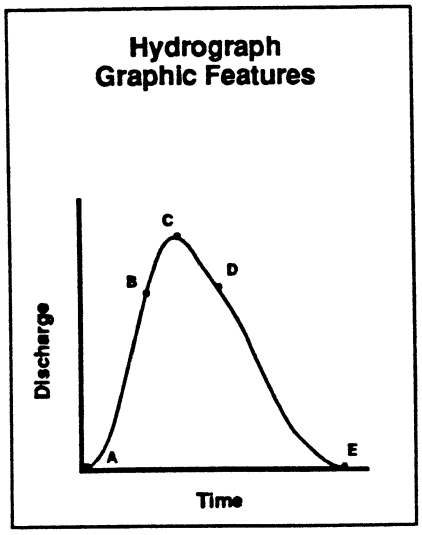
   b. Unit hydrograph

   c. Dimensionless unit hydrograph

   d. Synthetic unit hydrograph

   e. Dam Breach hydrograph

3. Identify the various hydrograph components shown on the following three hydrographs:



A. Point of raise

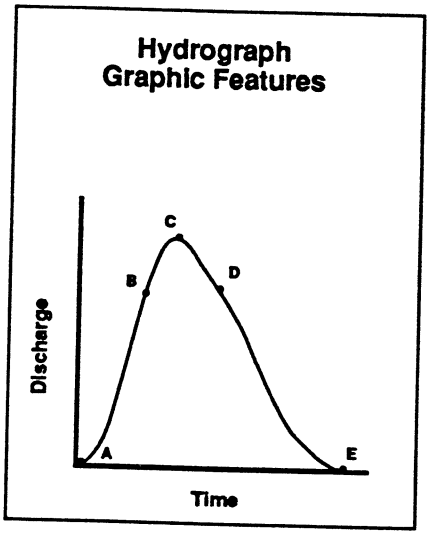
B. Rising point of inflection

C. Peak point

D. Recession point of inflection

E. End point of recession

3. *Continued*

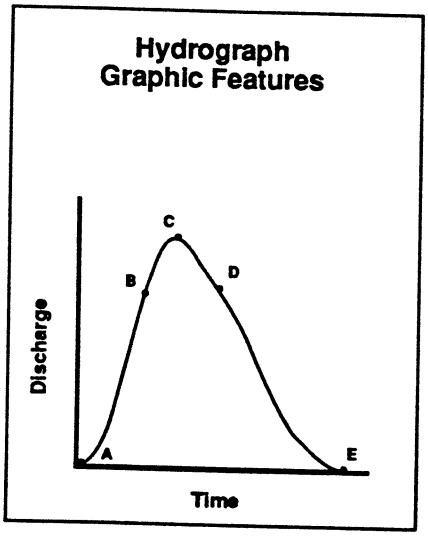


A - C Rising limb

C - E Recession Limb

B - D Crest segment

A - E Base time of hydrograph



ABCDEA Volume of runoff

Uses of Hydrographs

Common SCS uses of hydrographs include:

1. Watershed evaluations.
2. Design of structural works.
3. Flood plain management studies.
4. Emergency action plans.
5. Design of farm ponds.
6. Channel design.
7. Grade stabilization structures.

The primary purpose of using hydrograph analysis is to ensure a safe design of structural works. Hydrographs are an integral part of SCS procedures in the Water Resources Program. Hydrographs, or some feature of them, such as peak discharge, are used in the planning and design of water control structures.

Activity 2

At this time, complete Activity 2 in your Study Guide to review the material just covered. After finishing the Activity, compare your answers with the solution provided. When you are satisfied that you understand the material, continue with the Study Guide text.

Activity 2

1 List five uses made of hydrographs in the SCS.

a _____evaluations

b Design of _____

c. Flood plain _____

d Emergency _____

e Farm _____

2 The primary purpose of using hydrograph analysis is to ensure a safe _____of structural works. Hydrographs are an integral part of SCS procedures in the _____ _____ Program. Hydrographs, or some feature of them such as peak discharge, are used in the planning and design of_____ _____structures.

Activity 2 – Solution

1 List five uses made of hydrographs in the SCS.

a watershed evaluations

b Design of structural wprks

c. Flood plain management stuidies

d Emergency action plans

e Farm ponds

2 The primary purpose of using hydrograph analysis is to ensure a safe design of structural works. Hydrographs are an integral part of SCS procedures in the Water Resources Program. Hydrographs, or some feature of them such as peak discharge, are used in the planning and design of water control structures.

Summary

At this point you should be able to:

1. Define a hydrograph.
2. List the various types of hydrographs.
3. Define the various hydrograph components.
4. List the uses of hydrographs in the SCS.

This, of course, is an introductory module. If you need to learn more about hydrograph development, you should complete Module 207 - Hydrograph Development and perhaps Module 214B - Breach Hydrograph (Studies). These are "how-to-do-it" modules.

Retain this Study Guide as a reference until you are satisfied that you have successfully mastered all the methods covered. It will provide an easy review at any time if you should encounter a problem.

If you have had problems understanding the module or if you would like to take additional, related modules, contact your supervisor.

When you are satisfied that you have completed this module, remove the Certification of Completion sheet (last page of the Study Guide), fill it out, and give it your supervisor to submit, through channels, to your State or NTC Training Officer.

Hydrology Training Series
Module 107
Hydrographs

CERTIFICATION OF COMPLETION

This is to certify that

_____

completed Hydrology Training Series
Module 107
Hydrographs

on _____ and should be credited with 1 hour of training.
Date

Signed _____ _____
Supervisor/Trainer Participant

Completion of Hydrology Training Series
Module 107 – Hydrographs, is acknowledged
and documented in the above-named employee's record.

Signed _____ _____
Training Officer Date